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(54) Safety relief valve

(57) In a pressure relief valve comprising a stepped piston (36) with a reduced-area end portion (A4) and an enlarged-area end portion (A5), pressure from the main line (32) is directed into a chamber (42) to act on the enlarged area of the piston to force the reduced-area end into sealing contact with a valve seat (38). The enlarged area end portion of the piston (36) is sealed against back pressure in the exhaust line (34). As shown when mainline pressure P_4 exceeds a predetermined limit, a pilot valve (40) opens to vent chamber (42) and allow mainline pressure to force piston (36) from its seat.

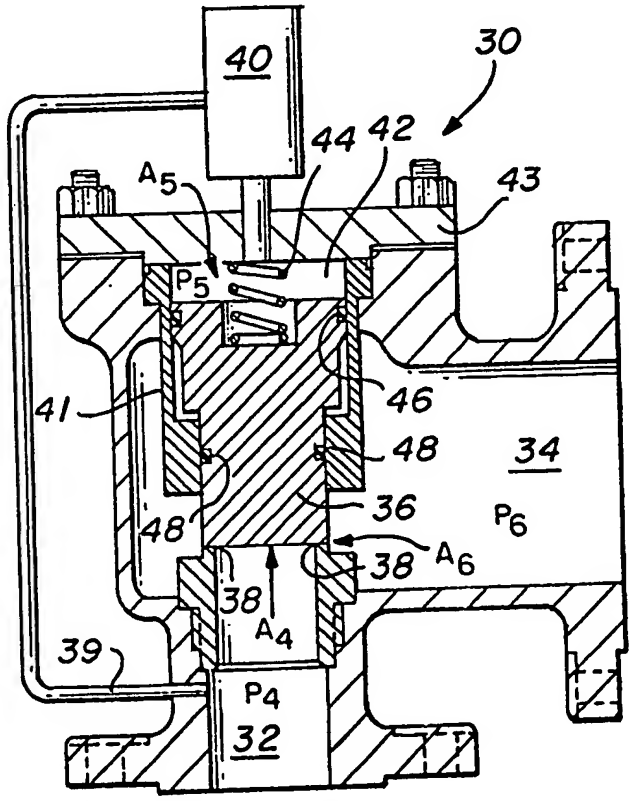

FIG. 2

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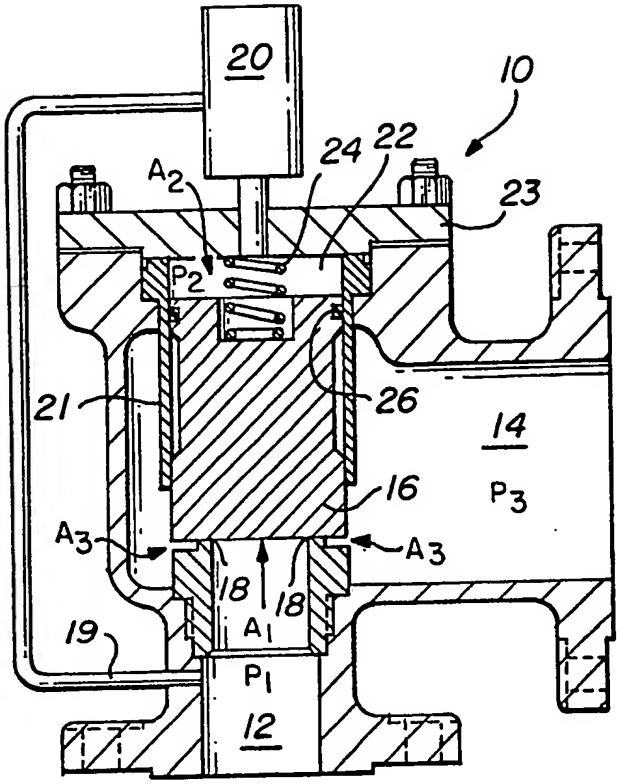

FIG. 1
PRIOR ART

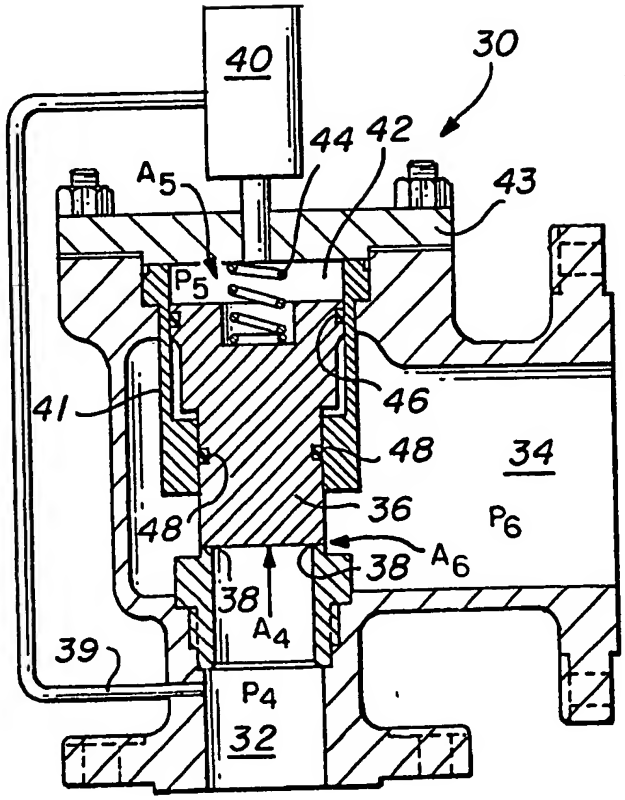

FIG. 2

STEPPED PISTON FOR BALANCED PILOT OPERATED SAFETY RELIEF VALVE

TECHNICAL FIELD

This invention relates to pressure relief valves and, in particular, to a balanced pilot operated safety relief valve having a main valve comprising a differential area stepped piston to eliminate the need for a back flow preventer device.

BACKGROUND OF THE INVENTION

Pressure relief valves of the differential area piston type have a main valve piston which engages a seat to seal a pressurized line or vessel. The main valve piston is slidably disposed within a pressure chamber or dome. Pressure from the main pressure line is routed through a pilot valve and into the pressure dome. Under normal conditions the pressure in the dome equals the pressure in the main line. Because the area of the piston in the dome is greater than the area circumscribed by the valve seat, the pressure in the dome holds the valve piston against the seat as long as the dome pressure equals the main line pressure.

The pilot valve, which is connected between the main line and the dome, functions to vent the pressure in the dome when the main line pressure reaches a predetermined level. Venting the pressure in the dome allows the main line pressure to force the piston away from the valve seat, thereby venting the main line into an exhaust line. When the main line pressure drops to a predetermined level, the pilot valve functions to repressurize the dome, thereby closing the main valve by forcing the piston onto the valve seat.

A deficiency of conventional relief valve piston design is that the area of the piston on the exhaust line side of the valve seat is exposed to back pressure in the exhaust line which counteracts the dome pressure. Since the area of the piston exposed to the main line pressure plus the area exposed to the exhaust line pressure is approximately equal to the area of the piston in the dome, an exhaust line

pressure above the main line pressure will combine with the main line pressure to counteract the dome pressure and urge the piston off the valve seat, thereby allowing exhaust line pressure to vent into the main line. To prevent this undesirable event, pressure relief valves of previous design have included a back flow preventer device to allow the main valve to remain sealed in the presence of high exhaust line back pressure.

The back flow preventer device is necessary in prior art relief valves because simply reducing the area of the valve piston exposed to exhaust line pressure necessarily increases the area of the valve piston exposed to the main line pressure. As the area of the piston exposed to main line pressure approaches the area of the piston in the dome, the force differential is reduced to a point where the seal at the valve seat leaks.

Therefore, to reduce the cost and complexity of conventional pilot operated safety relief valves, an improved main valve piston is needed to eliminate the necessity for a back flow preventer device.

SUMMARY OF THE INVENTION

The present invention is a balanced pilot operated safety relief valve that employs a main valve comprising a differential area stepped piston to eliminate the need for a back flow preventer device.

The stepped piston of the present invention comprises a reduced area end portion for sealing on the valve seat between the main pressure line and the exhaust line. A stepped-up enlarged area end portion of the piston is slidably disposed within a pressure chamber or dome. The dome comprises a cylindrical cavity bounded by a sleeve and a top plate mounted to the housing of the main valve. The sleeve comprises an enlarged bore forming the cavity containing the enlarged area end portion of the piston and a reduced bore for guiding the reduced area end portion of the piston onto the valve seat. A seal is placed between the reduced area end portion of the piston and the sleeve at the reduced bore for preventing back pressure in the exhaust line from acting on the enlarged area end portion of the piston in the dome. When the main valve piston is seated on the valve seat, an area of the piston on the exhaust line side of the valve seat is exposed to counteracting back pressure. This area may be reduced to near zero, however, because the area of the stepped piston exposed to the main line pressure at the valve seat always remains less than the enlarged area of the piston exposed to the system pressure in the dome. Thus, the area of the piston exposed to the exhaust line back pressure can be reduced significantly without reducing the force holding the piston against

the valve seat. As a result, the need for a separate back flow preventer device is eliminated.

BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of the present invention and for further advantages thereof, reference is now made to the following Description of the Preferred Embodiment taken in conjunction with the accompanying drawings, in which:

FIGURE 1 is a vertical cross-sectional view of a prior art pilot operated safety relief valve illustrating a main valve piston of conventional design; and

FIGURE 2 is a vertical cross-sectional view of a balanced pilot operated safety relief valve illustrating the differential area stepped piston main valve of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIGURE 1, a pilot operated safety relief valve 10 of conventional design is presented to illustrate the problem that is overcome by the present invention. The safety relief valve 10 includes a main pressure line 12 that is connected to a pressurized vessel or pipeline (not shown). The relief valve 10 further includes a pressure exhaust line 14 and a valve piston 16 that seats on a valve seat 18 to seal the main pressure line 12 from the exhaust line 14.

Pressure from main line 12 is routed through a pressure pickup line 19, through a pilot valve 20, and into a pressure chamber or dome 22. Dome 22 is bounded by a cylindrical sleeve 21, a top plate 23, and the piston 16. Piston 16 is slidably disposed within the sleeve 21. A coil spring 24 or other biasing means may be positioned in dome 22 to urge piston 16 onto the valve seat 18. A pressure P_2 in dome 22 is exerted against area A_2 of piston 16 to force piston 16 onto valve seat 18 to form a tight seal. A seal, such as O-ring 26, is provided to seal the pressure P_2 in dome 22 from exhaust line 14. A main line pressure P_1 is exerted against area A_1 of piston 16 in opposition to pressure P_2 in dome 22. Under normal conditions pressure P_1 in main line 12 equals pressure P_2 in dome 22. Therefore, since area A_2 is greater than area A_1, the net force on piston 16 forces piston 16 into a tight seal with valve seat 18. Furthermore, as pressure P_1 increases, the force of piston 16 on valve seat 18 also increases to maintain a tight seal.

When pressure P_1 in main line 12 exceeds a predetermined limit, pilot valve 20 functions to vent pressure P_2 from dome 22. With pressure P_2 vented from dome 22, the main line pressure P_1 acting on area A_1 forces piston 16 off valve seat 18 to vent main line 12 into exhaust line 14. When pressure P_1 drops below a predetermined level, pilot valve 20 closes to repressurize dome 22, thereby forcing piston 16 back onto valve seat 18.

In the conventional design of a balanced pilot operated safety relief valve illustrated in FIGURE 1, an area A_3 of piston 16 on the exhaust line side of valve seat 18 is exposed to any back pressure P_3 in exhaust line 14. The back pressure P_3 acting on area A_3 combines with pressure P_1 acting on area A_1 to oppose pressure P_2 acting on area A_2 in dome 22. Since area A_1 plus area A_3 is approximately equal to area A_2, a back pressure P_3 greater than main line pressure P_1 will force piston 16 off valve seat 18 allowing exhaust back pressure P_3 to vent into main line 12. This is a highly undesirable occurrence, and therefore safety relief valves of the type illustrated in FIGURE 1 must include a separate back flow preventer device (not shown) to enable piston 16 to remain seated on valve seat 18 regardless of the magnitude of pressure P_3 in exhaust line 14.

The present invention, which eliminates the need for a separate back flow preventer device, is illustrated in the safety relief valve 30 of FIGURE 2. Safety relief valve 30 includes a main pressure line 32, an exhaust line 34, and a differential area stepped piston 36 for seating on a valve seat 38 to seal the main line 32 from the exhaust line 34. A

pressure P_4 in the main pressure line 32 is exerted on an area A_4 of the piston 36 and is routed through a pressure pickup line 39, through a pilot valve 40, and into a pressure chamber or dome 42. Dome 42 is bounded by a cylindrical sleeve 41, a top plate 43, and the piston 36. Piston 36 is slidably disposed within the sleeve 41, which has an enlarged bore forming the dome 42 and a reduced bore opening into dome 42. A coil spring 44 or other biasing means may be positioned in dome 42 to urge piston 36 onto valve seat 38. A pressure P_5 in dome 42 is exerted on an area A_5 of piston 36 to force piston 36 into a tight seal with valve seat 38. A seal, such as O-ring 46, is provided to seal pressure P_5 in dome 42 as piston 36 reciprocates within sleeve 41.

The piston 36 of the present invention has a differential area stepped design with a reduced area end portion extending through the reduced bore of sleeve 41 and having an area A_4 for seating on valve seat 38, and an enlarged area end portion having an area A_5 confined entirely within the dome 42. An additional seal 48, which may comprise an O-ring, a diaphragm, or a bellows seal, for example, is provided to prevent any back pressure P_6 in exhaust line 34 from acting on the enlarged portion of piston 36 in the sleeve 41. In contrast to piston 16 in safety relief valve 10 of FIGURE 1, area A_6 of stepped piston 36 on the exhaust line side of valve seat 38 may be reduced to substantially zero. Even with area A_6 reduced to zero, area A_4 remains less than area A_5 so that pressure P_5 (which normally equals pressure P_4) acting on area A_5 in dome 42 provides a net force to maintain stepped piston 36

seated tightly on valve seat 38. Furthermore, back pressure P_6 can only act on the very small (or zero) area A_6 to oppose pressure P_5 in dome 42. Thus, pressure P_6 must be greatly in excess of main line pressure P_4 to force piston 36 off valve seat 38. As a result, the differential area stepped piston 36 prevents any back flow of pressure P_6 into main line 32 without the need for a separate back flow preventer device.

Although the present invention has been described with respect to a specific embodiment thereof, it is apparent that various changes and modifications may be suggested to one skilled in the art and it is intended that this invention encompass such changes and modifications as fall within the scope of the appended claims.

CLAIMS

1. A safety relief valve, comprising:

a housing for connecting a main pressure line to an exhaust line;

a valve seat mounted on said main line in said housing;

a cylindrical sleeve mounted in said housing to form a chamber;

a differential area stepped piston comprising a reduced area end portion for seating on said valve seat and an enlarged area end portion slidably disposed in said sleeve for reciprocation within said chamber;

means for directing pressure from said main line into said chamber, the pressure from said main line acting on said enlarged area end portion of said stepped piston to force said reduced area end portion of said piston into sealing contact with said valve seat; and

means for sealing said chamber from back pressure in said exhaust line.

2. The safety relief valve of Claim 1, wherein the area of said reduced area end portion of said piston on the exhaust line side of said valve seat exposed to back pressure counteracting the pressure in said chamber is essentially zero.

3. The safety relief valve of Claim 1 or Claim 2, wherein said sleeve comprises:

an enlarged bore forming said chamber; and

a reduced bore through which said reduced area end portion of said piston slidably extends to seat on said valve seat.

4. The safety relief valve of Claim 3, wherein said sealing means comprises a first seal disposed between said reduced end portion of said piston and said reduced bore of said sleeve.

5. The safety relief valve of Claim 4, wherein said first seal comprises an O-ring seal.

6. The safety relief valve of Claim 4 or Claim 5, wherein said sealing means further comprises a second seal disposed between said enlarged end portion of said piston and said enlarged bore of said sleeve.

7. The safety relief valve of Claim 6, wherein said second seal comprises an O-ring seal.

8. A pilot operated safety relief valve for venting excess pressure from a main line into an exhaust line, comprising:

a housing having a cylindrical sleeve mounted therein to form a chamber;

a valve seat mounted in said housing between the main line and the exhaust line;

a differential area stepped piston having a reduced area end portion for seating on said valve seat and an enlarged area end portion slidably disposed in said sleeve for reciprocation within said chamber;

a pilot valve for directing pressure from the main line into said chamber to force said piston into sealing contact with said valve seat; and

sealing means between said reduced area end portion of said piston and said sleeve for sealing said chamber and said enlarged area end portion of said piston from exposure to back pressure in the exhaust line.

9. The pilot operated safety relief valve of Claim 8, wherein said sleeve comprises an enlarged bore forming said chamber and a reduced bore through which said reduced area end portion of said piston slidably extends to seat on said valve seat.

10. The pilot operated safety relief valve of Claim 9, wherein said sealing means comprises an O-ring seal placed between said reduced area end portion of said piston and said reduced bore of said sleeve for providing a seal as said piston reciprocates.

11. The pilot operated safety relief valve of Claim 9 or Claim 10, further comprising a second sealing means for providing a seal between said enlarged area end portion of said piston and said enlarged bore of said sleeve as said piston reciprocates in said sleeve.

12. The pilot operated safety relief valve of Claim 11, wherein said second sealing means comprises an O-ring seal.

13. A pilot operated safety relief valve for venting excess pressure from a main line into an exhaust line, comprising:

a housing having a cylindrical sleeve mounted therein to form a chamber;

a valve seat mounted in said housing between the main line and the exhaust line;

said sleeve having an enlarged bore forming said chamber and a reduced bore opening into said chamber;

a differential area stepped piston having an enlarged area end portion slidably disposed within said chamber and a reduced area end portion extending slidably through said reduced bore for seating on said valve seat;

a pilot valve for directing pressure from said main line into said chamber to force said piston into sealing contact with said valve seat;

a first O-ring seal disposed between said reduced bore and said reduced area end portion of said piston for sealing said chamber from back pressure in said exhaust line; and

a second O-ring seal disposed between said enlarged bore and said enlarged area end portion of said piston.

14. A safety relief valve substantially as hereinbefore described with reference to and as shown in Figure 2 of the accompanying drawings.

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